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REVIEW OF S. A. FARBMAN'S AND I. F. KOLOBNEV'S BOOK "INDUCTION FURNACES FOR MELTING METALS AND ALLOYS"

G. V. Dershvarts
Cand Tech Sci

A third edition of S. A. Farbman's and I. F. Kolobnev's book has been published. While the first two editions (1933 and 1936) covered only the melting of nonferrous metals, the latest edition also examines the melting of ferrous metals in induction furnaces. This book is the most complete one available on furnaces with steel cores. It is intended for a wide circle of readers and is clearly written.

The book consists of three parts. The first is an examination of refractory materials (Chapter I) and types of induction furnaces (Chapter II). This part has some defects.

In the section on induction furnaces with steel cores, the authors, quite correctly, mention experiments on using closed-channel furnaces to remelt cast-iron tailings; these experiments, on the whole, were successful. It is, therefore, all the more strange to read on p 19 that such furnaces are unsuitable for melting ferrous metals. The authors conclude (p 25) that horizontal-channel furnaces, having less static head caused by the metal, "facilitate" thermal circulation of the metal and melt a charge quicker than vertical-channel furnaces. It is impossible to agree with this, for only forces of a vortex nature are capable of causing circulation of metal in an enclosed space. One also encounters isolated annoying vulgarizations, e.g., "... the conductor, along which the current flows, experiences a pinch effect from the elastic lines of force of the magnetic field."

The second part, the largest in the book, is devoted to furnaces with steel cores, and is the best. Nonetheless, even here there are some defects which should be removed in subsequent editions. In the first place, mention should be made of methods of designing these furnaces. In this regard, we consider the most important problem to be the determination of the leakage

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reactance and the active resistance of the metal in the melting channel. Calculating the active resistance of the passage is done by Rayleigh's method, using the concept of "depth of current penetration." As has been pointed out many times, this approach is erroneous; therefore, it is not surprising that the true resistance of the melting channel differs considerably from the calculated value. The treatment of the problem of calculating the leakage reactance is still worse. An induction furnace with a steel core is a very special kind of transformer.

The leading work on the theory of leakage in transformers has been done by Soviet scientists. Therefore, it is not clear why the authors recommend Nagaoka's formula for calculating leakage resistance (p 218), especially since it applies to cylindrical, single-layer coils without steel. The methods used for calculating leakage in transformer construction should be developed and adapted to the needs of persons designing electric furnaces with steel cores. On the other hand, the authors try to apply some "geometric" laws of transformer construction to furnaces with steel cores. This cannot be done because the furnace is primarily a metallurgical unit, and the laws of transformer geometry as applied to these furnaces would have to be much more flexible.

There are also some contradictions. For example, in a procedure for estimating the resistance of the primary winding of the furnace transformer (p 204), it is recommended that the dc resistance be increased by 15% to allow for skin effect. This is incorrect, for skin effect depends on the geometrical dimensions of the copper used for the winding and its position with respect to the core. The authors give a full account of this, and, on p 216, give an expression which enables one to obtain a first approximation of the primary-winding resistance. However, no practical conclusions are drawn from this which can be applied to the design of the primary winding. It should have several layers and be such that the radial dimension of the copper is not more than 9-10 mm (at a frequency of 50 cycles), while the axial dimension is dictated by the current density, or, more accurately, by the permissible value of the electrical efficiency and the method of cooling the primary winding. The authors, however, advise the reverse (p 98).

There are no generalizations in Chapter IV, which is given to an examination of the movement of metal under the action of electrodynamic and thermal forces. The electrodynamic forces which cause the various effects (centrifugal effect, motor effect, pinch effect, eddy effect), are examined only from the standpoint of their very special manifestations. Therefore, no mention whatever is made of the problem of the necessary condition which the field must satisfy so that electrodynamic agitation can take place. Neither is there any information on the change in pressure (even in the case of the pinch effect) with increase in cross section or frequency.

In deriving the formula for motor force in a triangular channel, Biot-Savart's law is written incorrectly, but further on another mistake is made in writing the expression for the length of a conductor; as a result of combining these two errors, formula (27) is correct.

When discussing materials for manufacturing cores, the authors do not mention the Soviet sorts of texturized steel which permit the use of high induction because of their low losses.

In two-channel furnaces with steel cores, the furnace transformer is usually Scott-connected. The authors frequently state, e.g., p 115, that this system ensures uniform-phase loading in a three-phase circuit. This is incorrect, for, as a result of the difference in the number of turns on the main and teaser transformer, the values given for the resistances of the channels are also different. As this system in general is not very stable when the load shifts, it is impossible to say that the network is uniformly loaded.

In the exposition of the problems associated with spark-gap oscillators, double-loop circuits should have been discussed, since they are considerably more economical than single-loop circuits. Mention should also have been made of stationary dischargers with several spark gaps. Little space is devoted to vacuum-tube oscillators, and therefore inevitable distortions of the physical process of their operation have appeared in the text.

Furnace designs are examined very carefully, even though the material is prewar.

Vacuum furnaces have now become industrial units. This should have been pointed out. All the designs of this section (with the sole exception of I. F. Kolobnev's furnace) are more or less obsolete. When calculating the cost of capacitors, modern types should have been taken as examples. In the case of paper-oil and ceramic capacitors, the reduction in cost per kilovolt-ampere and the increase in reactive power per unit of volume are impressive.

The technology of making mixes for the fettling is discussed in great detail as are foundry equipment and casting technique, e.g., continuous casting of aluminum alloys.

The book gives a number of practical calculations of induction furnaces for melting various metals. Unfortunately, the authors do not use a uniform system of units. They seem to prefer the electromagnetic system, which is not generally used in engineering practice.

The appendices give much useful material on the physical properties of refractories and molten metals.

The isolated defects mentioned above do not detract from the value of the book, which can be used by persons working on the design and operation of induction furnaces.

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